Challenges to monitoring recovery of an endangered species

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Figure 1

Challenges

- Adaptive and flexible metrics of recovery
- Spatial structure
- Community background
- Anthropic changes and other trends
- Efficient design for monitoring
- Quantifying evidence for models
- Prediction in a multiple model framework
- Mixed model estimation for multiple potentially non-normal random effects

Figure 2

PVA based Recovery Measures

- Mean time to extinction
  - Mean of skewed distribution influenced by rare events
- Probability of extinction before time C
  - What happens after time C?

Figure 3

Difficulties with traditional PVA measures

- Both extrapolate beyond range of data
  - Allee effects
  - High density discrepancies
- Both assume constant environment
  - Invalidated by trends in population parameters
    - Habitat disruption
    - Community change

Figure 4

Alternative measures

- Lower population level of concern is flexible
  - Need not be extinction
  - Can be much higher
  - Extrapolation bias greatly reduced
- Time horizon reduced as well
  - Multiple scales e.g. 5, 25 and 125 year
- Complete PDF and CDF of time to threshold
  - if possible

Figure 5

Trends in PVA measures

- Continually updated PVA
- PVA more a measure of health than a prediction.
- Trends in expected extinction time or probability of extinction before C more informative than the measures themselves.
- Incorporate trends in parameters directly into models

Figure 6

Spatial Structure

- Spatial structure and connectivity critical
- Site specific
  - Fecundity, growth rates and survival
  - Proportion of resident and migratory life-histories
  - Age of emigration, age/size of return
  - Site fidelity

Figure 7

Spatial Structure

- Covariate based estimates of habitat quality
- Essential for creating a complete map of biological potential

Figure 8

Community Structure

- Increased Dynamic Variation
- Long period cycles
- Trends

Figure 9

Anthropic Impacts

- Habitat changes
  - Degradation
  - Improvement
- Climate change
- Direct take
- Species introductions
- Community management

Figure 10

Efficient Design for Data Collection

- Stochastic model of inter-connected populations
- Determine sensitivity of recovery measures to uncertainty in information about parameters through simulation and error propagation analysis
- Design data collection for maximum reduction in recovery measure uncertainty

Figure 11

Models and Evidence

- Complex environments and real biology
- Multiple models a necessity
  - Most error is due to model misspecification
- Classical Statistics does not handle well

Figure 12

Evidential Statistics

- A developing paradigm
- Compares evidence in data for one model over another.
- Does not assume a true model in set
- Evidence measures customizable for specific problems
- Likelihood Ratio and Information Criteria are special cases

Figure 13

Decisions under multiple models

- Not well developed
- Model redundancy
  - Ignored by AIC-weights and Bayesian-model averaging
  - Distorts multiple model inferences
- An important focus for future research

Figure 14

Decisions under multiple models

- Bootstrapping a possible solution
  - What to do in complex systems with multiple data streams?
- Model uncertainty can be incorporated in the calculation of prediction intervals!

Figure 15

Decisions under multiple models

- Models used should change through time
  - Or at least weightings
- Through time more data will be accumulated. More data will support more complex models.
- The decision process needs to be consistent through time not the models.

Figure 16

General mixed models

- Normal mixed models have revolutionized ecology
- Not as convenient for non normal problems
- Species recovery awash with random effects
  - Site variability, temporal variability, individual variability, sitability

Figure 17

Estimation for GMM

- Smoothed simulated composite likelihood
  - Stochastic optimization procedure
  - Computationally efficient
  - Guaranteed convergence to a unique solution
- Parameter estimation for any process that can be simulated
  - Even if full likelihood can not be written.
- Algorithm under construction. works. Beta version expected by year's end

Figure 18